Annual Production of Creek Chub and Southern Redbelly Dace in a Small Woodland Stream[1]

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ABSTRACT. The annual production of the creek chub, *Semotilus atromaculatus,* and southern redbelly dace, *Phoxinus erythrogaster,* was measured in a small headwater stream in southeastern Ohio. Creek chub annual production was 13.60 g $\cdot$ m^{-2} per yr, and $P/\bar{B}$ was 1.16. Dace annual production was 2.77 g $\cdot$ m^{-2} and $P/\bar{B}$ was 1.82. Even though the stream was acidic (pH 6.3) and infertile, fish production compared favorably with that of small alkaline streams. Considerable production within allochthonous food chains probably overrides the effects of low in-stream fertility.

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INTRODUCTION

The annual production of warm-water fishes in headwater streams has received considerably less attention than that of salmonids. As a result, the development of useful generalizations about rates of fish tissue elaboration in comparable habitats is limited. One reason is that fish production is partitioned among a larger number of species in warm-water streams (Mahon & Balon 1985). In addition, most of the estimates for cold-water streams are based on small streams while estimates for warm-water fish are usually from populations in larger streams. This paper estimates annual production for two warm-water species, the creek chub, *Semotilus atromaculatus,* and the southern redbelly dace, *Phoxinus erythrogaster,* in a small, unperturbed spring-fed, headwater stream in southeastern Ohio. Corroborative production data on warm-water fishes are needed before the ranges of production-to-biomass ratios ($P/\bar{B}$) will be available for comparison with those of cold-water species in headwater streams. For example, so few data are available that we cannot say that warm-water species will necessarily display the relative constancy in $P/\bar{B}$ values noted for cold-water species (Neves 1981, Scarnecchia & Bergerson 1987, Mahon & Balon 1985). The accumulation of such additional production data from unperturbed streams will eventually prove useful in establishing whether production rates are similar in headwaters containing cold- or warm-water species. The fish community studied consists of only three teleosts and one lamprey; thus, values will be more comparable to headwater salmonid communities (Neves et al., 1985, Scarnecchia & Bergerson 1987).

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STUDY AREA

Our study was conducted in Indian Creek, a tributary of Clear Creek, in Fairfield County, southeastern Ohio (Fig. 1). The entire area is forested. Indian Creek has a moderate gradient (7.7 m/km) and flows through a narrow, steep-sided valley. The stream enters a 4 ha man-made impoundment, Lake Ramona, whose spillway effectively isolates the fish populations of Indian

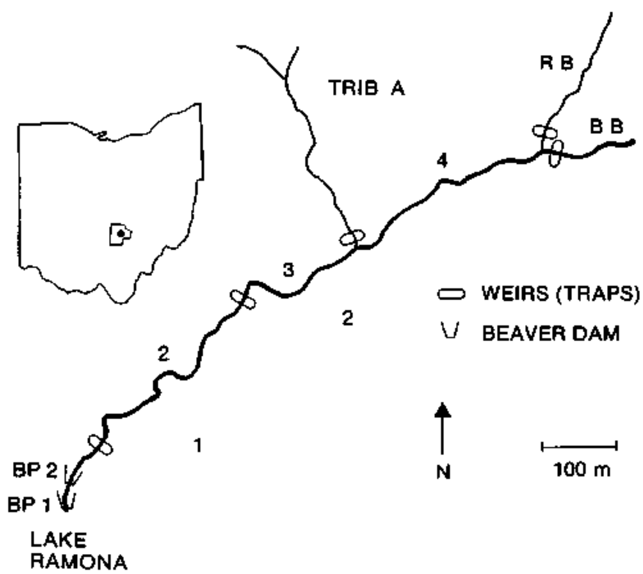

FIGURE 1. Indian Creek in August, 1972 showing tributary streams A, RB and BB as well as location of two beaver ponds, BP1 and BP2. The second beaver pond (BP2) and each tributary constituted study sections. Weirs incorporating traps were placed at five locations shown on the map (⬭) to monitor and/or prevent movement between study sections. The numbers 2, 3, and 4 correspond to study sections. See Storck and Momot 1981 for details.

Creek from Clear Creek. The portion of the stream above Lake Ramona consists of 2,300 m with a surface area of 0.4 ha. The main channel is a second order stream, whereas the three tributaries are first order. Two beaver ponds (Fig. 1) (BP1 and BP2) occur at the downstream end of Indian Creek. BP1 is somewhat isolated from the rest of the stream and is not considered in this study. The first tributary (Trib. A), which enters approximately 800 m upstream from BP2, is reduced to a series of isolated pools in summer. Indian Creek divides into two more tributaries at a point 1,200 m upstream from Lake Ramona. The road branch (RB) tributary has good pool development (12% of the linear distance being pools), and supports a substantial number of fish. During late summer dry periods, the flow frequently ceases in this section, producing isolated pools. The back branch (BB) tributary, which has almost no pool development (7% pools), is inhabited by only a few fish. During the study period, this tributary always maintained a flow. Physical measurements are given in Table 1.

Except for the beaver pond, the substrate of the stream was approximately 34% sand and 66% gravel and rubble, with little difference between sections (Stillwell 1974). Banks were fairly stable with 56% average stream bank vegetation stability determined using methods in Herrington & Dunham (1967). Oxygen levels were at saturation, and stream pH averaged 6.3. Carbon dioxide averaged 8 mg CO_2 L^{-1} and alkalinity as $CaCO_3$ was a consistent 20 mg L^{-1}. Calcium hardness was zero and magnesium hardness as $CaCO_3$ was only 5 mg L^{-1}. In addition to creek chub and southern redbelly dace, blacknose dace, *Rhinichthys atratulus*, were abundant. The least brook lamprey, *Lampetra aepyptera*, was also present, being most abundant in the first 500 m above BP2 (Stillwell 1974).

MATERIALS AND METHODS

Population estimates, using Bailey's modification of the Petersen mark-and-recapture method (Ricker 1975), were made for creek chub and redbelly dace in October 1971 and in April and October 1972 over the entire stream. A variable voltage, pulsating, direct-current electric shocker was the principal collecting gear, although small cylindrical minnow traps were also used in BP2. In October 1972, minnow traps and 1.2 m and 1.7 m minnow seines with 0.637 mm mesh size were employed to supplement electrofishing. The time between marking and recapture always exceeded 2 days and generally was 3 days. Captured fish were anesthetized with MS-222, measured to the nearest 1 mm total length, and in the marking censuses, were fin clipped, with the dorsal lobe or ventral lobe (Spring) notched. Separate population estimates were made for each stream section and for each age/length group, but because of their small size only fish 2 years old and older in April and 1.5 years old and older in October 1971 and 1972 were included.

TABLE 1

Physical measurements for reaches of Indian Creek, Fairfield County, Ohio in August 1972.

Section	Length (m)	Surface area (m^2)	Pool area (m^2)
BP2	198.0	1128	1016
2	296.0	462	184
3	278.1	445	126
4	436.0	654	157
A	321.3	353	79
RB	436.0	523	70
BB	273.0	300	---

To prevent bias due to immigration, population estimates were conducted at a time when migration was minimal (Storck and Momot 1981). Movement between sections was prevented by using blocking seines and wire rectangular migration traps (Fig. 1) that functioned as weirs, described in Storck and Momot (1981). Voltage of the electrofishing gear was held at a minimum effective level to reduce damage to fish. No dead fish were ever recovered after completion of the marking census.

Scales were not used for aging either creek chub or southern redbelly dace because the first annulus of known age fish could not be determined consistently. Instead, age was determined by plotting length-frequency histograms on probability paper (Cassie 1954). For the creek chub, the extensive overlap in length of older-year classes, the small number of these individuals captured, and the presumed difference in growth rate between sexes in later years (Greeley 1930) made separation of the older age groups difficult. Overlapping length distributions forced us to subjectively choose cut-off points to equalize the number of individuals assigned to successive age classes, thus assigning all smaller fish to younger- and all larger fish to older-year classes. The low numbers of age 3+ chubs in the fall and age 4+ in the spring necessitated that their numbers be calculated by forming a pooled estimate with the next younger-year class and then partitioning this estimate according to the ratio of abundance in the catch (McFadden 1961). Consequently, confidence limits could not be calculated for the oldest age group.

Only age 2+ and 3+ southern redbelly dace in the spring and age 1+ and 2+ dace in the fall were included in the population estimates. Probability age analysis of fall 1972 length-frequency data was not feasible (Storck 1974) because the assumption of equal distribution of fishing effort was not met, therefore, the 1971 length intervals were applied to the 1972 data. The length interval for the youngest age group was 38-60 mm and >60 mm (61-75 mm) for the older age group. These ranges did not increase between the fall and spring census.

Too few older dace were recaptured in the fall of 1971 and spring of 1972 to compute independent population estimates. Therefore, they were pooled with the younger age groups and their numbers determined by partitioning according to the ratio of their abundance in the catch. However, high recaptures of age II southern redbelly dace in fall 1972 obviated use of the partitioning technique discussed earlier.

Instantaneous mortality rates for six-month intervals were calculated for each age group using successive population estimates. Because population size at 0.5 and 1.0 years could not be determined by using the mark-and-recapture method, the abundance of these age groups was estimated by extrapolation from population size at age 1.5. Generally, mortality is highest in the first three months of life. Extrapolation of the survivorship curve for older age groups obtained from a similar plot produced a straight line fit. Therefore, mortality during the second and third summers of life was assumed equal, as was mortality during the first and second winters. The number of fry emerging from deposited eggs was measured (Storck 1974) and used to determine N_0 and thus anchor the estimate of mortality during the first six months of life. The semilog plot was then extrapolated backwards to estimate survival of these youngest age groups, i.e., <1.5 yr. Creek chub mortality beyond the fourth winter could not be estimated because of limitations imposed by the length-frequency method of age analysis.

Production was calculated by the instantaneous growth method (Ricker 1975). Mean length at age was estimated from probability paper plots of length-frequency distributions for both creek chub and southern redbelly dace. Mean weight was estimated from the length-weight relationship, calculated separately in the fall and spring for each species (Storck 1974). Biomass of the species in each stream section was estimated by multiplying numbers at age by the mean weight at age.

RESULTS AND DISCUSSION

Most growth in length and weight of both species occurred during the summer (Table 2). Creek chub grew faster than did redbelly dace, and by the fall of the fourth year of life, chubs were about five times heavier than dace of the same age.

TABLE 2

Mean lengths (ML) in mm and mean weights (MW) in g of creek chub and redbelly dace as determined from length-frequency by using probability paper and length-weight regressions (Storck, 1974)[1]

Age	October 1971 ML	October 1971 MW	April 1972 ML	April 1972 MW	October 1972 ML	October 1972 MW
CREEK CHUB						
0	41	0.50	--	--	37	0.38
1	58	1.65	38	0.40	56	1.43
2	88	6.29	57	1.45	87	5.89
3	116	15.27	88	6.18	117	15.27
4	140	27.30	117	15.80	149	33.23
REDBELLY DACE						
0	30	0.22	--	--		
1	50	0.96	31	0.22		
2	64	1.89	50	1.08		
3	74	2.82	65	2.64		

[1]Length-weight regressions were employed as follows:
LogL = 1.707 + 0.301 LogW (creek chub, Sp. '72)
LogL = 1.700 + 0.311 LogW (creek chub, F. '72)
LogL = 1.708 + 0.353 LogW (redbelly dace, Sp. '72).

Population size and biomass were estimated for each age group of each species in spring and fall (Tables 3 and 4). Biomass estimates for fish less than 1.5 years of age are not included because their distribution within the stream was not known.

CREEK CHUB. The beaver pond (BP2) contained 38 to 54% of the total creek chub biomass in Indian Creek (Table 4). The high density ($g \cdot m^{-2}$) in this section was exceeded only within section 2 during the fall of 1972 (Table 4). Spring density was somewhat overestimated throughout the stream except in BP2 because the stream has a greater surface area in spring than in late summer when stream measurements were actually made. The beaver pond, however, fluctuated minimally in surface area. Thus, the difference in the density of chubs in the spring between BP2 and other sections of the stream was even greater than that suggested in Table 4.

TABLE 3

Seasonal creek chub, Semotilus atromaculatus *and southern redbelly dace,* Phoxinus erythrogaster, *population estimates in Indian Creek, Fairfield County, Ohio, during 1971 and 1972. Data given as N (population size); C. I. = 95% confidence interval.*

Age (length range in fall)	Stream section	Fall 1971 N	Fall 1971 C. I.	Spring 1972 N	Spring 1972 C. I.	Fall 1972 N	Fall 1972 C. I.
CREEK CHUB							
I							
(44-77 mm)	BP2	1879	(1189-2569)	---	---	1770	(1422-2118)
	2	999	(657-1341)	---	---	1144	(916-1372)
	3	701	(501-901)	---	---	456	(344-568)
	4	947	(575-1319)	---	---	671	(473-869)
	A	84		---	---	144	(80-208)
	RB	221	(139-303)	---	---	212	(150-274)
II							
(72-105 mm)	BP2	349	(201-497)	1900	(1334-2466)	103	(66-140)
	2	112	(30-194)	531	(357-705)	110	(72-148)
	3	133	(69-197)	347	(265-429)	37	(51-72)
	4	225	(141-309)	660	(551-809)	109	(93-125)
	A	21	(4-38)	221	(67-375)	24	(13-35)
	RB	144	(85-203)	151	(107-195)	7	(2-12)
III							
(106-130 mm)	BP2	125	---	221	(152-290)	46	---
	2	26	---	57	(10-104)	36	---
	3	23	---	21	(11-33)	6	---
	4	19	---	71	(64-78)	10	---
	A	7	---	33	(9-57)	3	---
	RB	34	---	36	(24-48)	6	---
IV*							

*Population sizes for age IV fish in the six stream sections were calculated in spring, 1972 and were 84, 4, 4, 2, 9 and 15 respectively.

TABLE 3 (continued)

Age (length range in fall)	Stream section	Fall 1971 N	Fall 1971 C. I.	Spring 1972 N	Spring 1972 C. I.	Fall 1972 N	Fall 1972 C. I.
REDBELLY DACE							
I							
(38-60 mm)	BP2	266	(24-508)	---	---	377	(211-543)
	2	347	(51-643)	---	---	615	(493-737)
	3	371	(199-543)	---	---	330	(242-418)
	4	570	(324-816)	---	---	390	(278-502)
	A	54	(18-90)	---	---	86	(26-146)
	RB	143	(59-227)	---	---	79	(31-127)
II							
(61-75 mm)	BP2	160	---	350	(184-516)	289	(123-455)
	2	19	---	225	(37-413)	34	(25-43)
	3	30	---	252	(146-358)	40	(25-56)
	4	100	---	362	(244-480)	33	(17-49)
	A	4	---	33	(7-59)	16	(11-21)
	RB	12	---	308	(0-650)	21	(4-38)
III*							

*Population sizes for age III fish in the six stream sections were calculated only in Spring 1972 and were 229, 21, 15, 18, 6 and 38 respectively.

TABLE 4

Creek chub and redbelly dace biomass (g) and density ($g \cdot m^{-2}$) per reach in Indian Creek, Fairfield County, Ohio, during fall 1971 and spring and fall 1972 for each age group.

Season	Age Group	Stream section BP2	2	3	4	A	RB	Total
CREEK CHUB								
Fall 1971	I	2,762	1,469	1,030	1,392	125	325	7,103
	II	1,964	631	749	1,267	118	810	5,539
	III	1,909	397	351	290	107	519	3,573
	Total	6,635	2,497	2,120	2,959	350	1,654	16,215
	Density	5.9	5.4	4.8	4.5	1.0	3.2	
Spring 1972	II	2,755	770	503	957	320	219	5,524
	III	1,366	352	130	438	204	222	2,712
	IV	1,327	63	63	32	142	237	1,864
	Total	5,448	1,185	696	1,427	666	678	10,100
	Density	4.8	2.4	1.6	2.2	1.9	1.3	
Fall 1972	I	2,920	1,887	752	1,107	237	350	7,253
	II	647	691	233	685	151	44	2,451
	III	722	565	94	157	47	94	1,679
	Total	4,289	3,143	1,079	1,949	435	488	11,383
	Density	3.8	6.8	2.4	3.0	1.2	0.9	
REDBELLY DACE								
Fall 1971	I	256	333	356	548	52	138	1,683
	II	302	36	57	189	8	22	614
	Total	558	369	413	737	60	160	2,297
	Density	0.5	0.8	1.1	0.2	0.2	0.3	
Spring 1972	II	649	324	256	473	54	276	2,132
	III	634	58	42	50	17	105	906
	Total	1,283	382	398	523	71	381	3,038
	Density	1.1	0.8	0.9	0.8	0.2	0.7	
Fall 1972	I	363	591	317	375	83	75	1,805
	II	546	64	76	62	30	40	818
	Total	909	655	393	437	113	116	2,623
	Density	0.8	1.4	0.9	0.7	0.3	0.2	

The total biomass of age I+ and older creek chubs in Indian Creek was greater in fall 1972 than in spring. However, decreased fall biomass in BP2 (Table 4) reflected considerable upstream migrations during spring and early summer into section 2 where density increased from 12 to 28% of the stream total (Storck and Momot 1981). Hence, most of the chubs leaving BP2 in spring terminated their upstream movement in section 2 (Storck and Momot 1981).

The total chub biomass decreased 35% between fall 1971 and fall 1972 despite a small increase in the biomass of 1-year-old fish (Table 4).

Creek chub production between fall 1971 and fall 1972 was 50,032 g or 13.60 g $\cdot$ m^{-2}, with approximately 70% and 87% occurring by the end of the first and second summer of life, respectively (Table 5). The P/B ratio for creek chub was 1.16.

SOUTHERN REDBELLY DACE. Density (g $\cdot$ m^{-2}) was high in BP2 relative to the rest of the stream during spring but was lower than that in sections 2, 3, and 4 in fall (Table 4).

Unlike the creek chub, the biomass of age I+ and older dace did not decrease between fall and spring, reflecting low winter mortality and an increase in individual weight (Table 4). Dace biomass increased 14% from fall 1971 to fall 1972, whereas creek chubs suffered a 35% decrease.

Annual dace production was 10,216 g (2.77 g $\cdot$ m^{-2}) (Table 5), approximately 20% of the creek chub value. Sixty-three percent of the total production occurred by the end of the first summer of life and about 90% by the end of the second summer. The total annual production of dace in Indian Creek was substantially less than that of the creek chub because: 1) fewer fry were produced (Table 5), 2) the mortality rate of age 0 fish was greater, and 3) growth was slower for all comparable age groups (Table 2). The P/B ratio for dace, based on the mean summer biomass estimate, was 1.82 (Table 6).

Besides a need for accurate population estimates to measure biomass and production, growth and mortality models must accurately describe changes in number and mean weights of individual age groups. Though instantaneous rates are suitable for periods of a few months, they become increasingly inaccurate with increasing estimate intervals. In Indian Creek, a six-month interval between estimates was suitable for winter calculations because little or no growth took place at that time, but from April through September, growth and mortality rates were more variable. An additional population estimate during this interval would have further increased the accuracy of those production estimates.

TABLE 5

Annual production of creek chub and redbelly dace in Indian Creek (1971-1972). N = population size, Z = instantaneous mortality, W(t) = mean weight, G = instantaneous rate of growth, B_o = initial biomass, B = mean biomass, and P = GW, production in grams.

Age	N(t)	Z	W(t)	G	B_o	B	P
CREEK CHUB							
0.0	224,000		0.01		2,240		
		1.55844		3.91202		9,064	35,455
0.5	47,144		0.50		23,572		
		1.16959		0.00000		13,896	0
1.0	14,638		0.40		5,855		
		1.10857		1.41707		6,859	9,720
1.5	4,831		1.65		7,971		
		1.16959		0.00000		4,699	0
2.0	1,500		1.45		2,175		
		1.09861		1.46740		2,630	3,859
2.5	500		6.29		3,145		
		1.13943		0.00000		4,134	0
3.0	160		6.18		989		
		1.16315		0.90457		871	788
3.5	50		15.27		764		
		0.82098		0.03412		529	18
4.0	22		15.80		348		
		0.52610		0.54688		352	192
4.5	13		27.30		355		
Total						43,034	50,032
g $\cdot$ m^{-2}							13.60
REDBELLY DACE							
0.0	179,100		0.01		1,791		
		2.8078		3.09104		2,070	6,398
0.5	10,807		0.22		2,377		
		0.2014		0.00000		2,153	0
1.0	8,836		0.22		1,944		
		1.5492		1.47330		1,872	2,758
1.5	1,877		0.96		1,802		
		0.2044		0.11778		1,726	203
2.0	1,530		1.08		1,652		
		1.5492		0.55962		1,049	587
2.5	325		1.89		614		
		0.0000		0.33420		729	244
3.0	327		2.64		863		
		1.8780		0.06595		398	26
3.5	50		2.82		141		
Total						9,997	10,216
g $\cdot$ m^{-2}							2.77

TABLE 6

Seasonal variation in creek chub and redbelly dace total annual biomass and production-to-biomass ratios ($P/\bar{B}$) for Indian Creek (1971-1972).

Summer	Total biomass (g)	$g \cdot m^{-2}$	$P/\bar{B}$
CREEK CHUB			
Spring	11,607	3.00	4.72
Summer	19,838	5.13	2.76
Fall	35,807	9.26	1.53
Winter	23,285	6.02	2.35
REDBELLY DACE			
Spring	6,690	1.73	1.55
Summer	5,688	1.47	1.82
Fall	4,935	1.28	2.09
Winter	5,103	1.32	2.03

More than half of the production of both species was estimated to occur within the first six months of the life of the cohort. The point estimates at the beginning and end of this interval are the least accurate of the estimates of any age group, and because of rapid changes in growth and mortality rates during this time, it is unlikely that the exponential model accurately described changes in biomass over the entire life cycles. Mahon et al. (1979) have demonstrated that large errors in production calculations may result from slightly different treatment of the 0+ age class.

Depite the large contribution of age 0+ fish to the total production of the population, we were unable to improve the accuracy of these estimates. Creek chubs and dace in this stream are simply too small to be sampled efficiently until the fall of their second year of life.

Estimates of production are generally recorded as weight per unit surface area. In Indian Creek, surface area was measured only during late summer when the stream was somewhat lower. This slightly inflated the production estimate.

Despite these sources of error, some comparisons of our annual production biomass and $P/\bar{B}$ ratios estimates can be made with other creek chub populations, other estimates for warm-water species and with cold-water species living in somewhat similar habitats (1st and 2nd order headwater streams). Only two other published annual production estimates are available for creek chubs, that of Lotrich (1973) for three Kentucky streams and Mahon et al. (1979) for a southern Ontario Stream, the Speed River. Of these, only Lotrich's estimate for a 1st order Kentucky stream is directly comparable to our estimate since the Speed River is a much larger (4th order) stream. Lotrich's estimates of 8.6 $g \cdot m^{-2}$ for a 1st order Kentucky stream was below that of Indian Creek (13.6 $g \cdot m^{-2}$). Lotrich's estimates for a 2nd and 3rd order Kentucky stream were also lower, 10.6 and 7.7 $g \cdot m^{-2}$, respectively, as were the ranges of Mahon et al. (1979) estimates (.09-.84 $g \cdot m^{-2}$) for various portions of the Speed River. In that river, creek chubs comprise only 25% of the total fish biomass; however, even the combined production for all species was only 20% of the total production estimated for creek chub alone in Indian Creek. Neves (1981) summarized production estimates for individual species in warm-water streams as falling between 0.2 to 17.8 $g \cdot m^{-2}$. Only two of these estimates exceed values for the creek chub in Indian Creek. Estimates for total fish production in warm-water streams range from 3.07 to 50.12 $g \cdot m^{-2}$ for a series of 14 Polish and 11 Canadian (Ontario) streams (Mahon & Balon 1985). However, almost all of these streams were much larger (mean widths were 9.1 m for Polish streams and 18.0 m for Ontario streams) and species richness was far greater than in Indian Creek. A more meaningful comparison might therefore be made between Indian Creek, a warm-water headwater stream and other cold-water headwater streams. Scarnecchia and Bergerson (1987) provide data on production and biomass of various salmonids (4 species) in ten small Colorado streams varying in mean width from 0.6 to 4.7 m compared to Indian Creek with a mean width of 1.95 m. All but two of those streams were 2nd or 1st order streams, and so can be compared with Indian Creek. Production varied from 1.7 to 12.6 $g \cdot m^{-2}$ in 1979 and 1.5 to 18.4 $g \cdot m^{-2}$ in 1980, compared with a production of 13.6 $g \cdot m^{-2}$ in Indian Creek. In two of the Colorado streams with alkalinities similar to Indian Creek, production was 3.3-2.3 $g\ m^{-2}$ and 3.6-1.5 $g \cdot m^{-2}$. They found $P/\bar{B}$ ratios to vary from 0.23 for Right Fork Creek, dominated by large Cutthroat trout, *Oncorhynchus clarki*, to 0.95 for McCreary Creek which contained many young-of-the year brook trout, *Salvelinus fontinalis*. In all of these 1st to 3rd order trout streams, trout were the terminal predators. Their production and $P/\bar{B}$ ratios fell below that of creek chub, the terminal predator in Indian Creek. It would appear that within streams of similar order and size that production values for terminal predators depend upon growth rates, mean age and length of life cycle rather than biomass density. Furthermore, the lower $P/\bar{B}$ ratios in cold-water streams are a function of a large biomass of small, old, slow-growing fish. Although they felt that stream conductivity values are usually associated with higher production in trout streams, such chemical influences on production over narrow ranges of variation may be dominated or obscured by physical habitat influence. When they attempted to correlate chemical factors to production in their study streams, the correlations were weak. Physical factors appeared to be more important; of particular significance in the smallest streams was the overall width:depth ratio. A lower ratio results in more production per unit surface partly because fish production involves growth and survival in three dimensions, whereas production is usually expressed in two dimensions (Scarnecchia and Bergersen 1987). This finding was consistent with reports by Mortensen (1977) and Le Cren (1969). Three of four of the most productive 1st order streams studied by Scarnecchia and Bergersen (1987) had lower average width:depth ratios than other streams examined. These ratios ranged from 6.7 to 14.5 over 2 years. Production was calculated at 4.8-18.4 $g \cdot m^{-2}$ in these streams. The most productive stream, McCreavy, had a production of 12.6 and 18.4 $g \cdot m^2$ consisting mostly of one species, brook trout. It also had the lowest width: depth ratio. In comparison, Indian Creek has an even lower width:depth ratio of 2.1. Although production and biomass were estimated for only two of the three teleosts present, blacknose dace, the third species, have an age structure similar to that of redbelly dace, and are equally abundant (Storck 1974). Their biomass and production may be similar. If so, the total teleost production may approach 18.9 g $\cdot$ m^{-2}, a value similar to that found in McCreavy Creek, Colorado. The difference is that Indian Creek is chemically a low nutrient, acidic stream, yet has as high a production as McCreavy Creek and higher than in most of the warm-water streams reported by Neves (1981). Both Neves (1985) and Scarnecchia and Bergersen (1987) suggest that low fish production is to be expected in low nutrient streams. However, this generalization is based on their study of high gradient mountainous streams (in the Rockies and Southern Appalachians) subject to seasonal flooding. Such seasonal flooding is an important factor influencing fish food production in streams (Elwood and Waters 1969). Indian Creek is heavily forested with deciduous trees and such streams are predominantly heterotrophic, i.e., the food base is derived mainly from an external energy source (Minshall et al. 1983). The contribution of terrestrial invertebrates and leaves, which serve as a direct or indirect food source for aquatic insects, exceeds the production of autochthonous materials. The high fish production in Indian Creek is not surprising. In fact, production per unit area in small woodland streams may be just as high as in large streams simply because allochthonous input per unit of surface area is greater. Certainly the per area production reported by Scarnecchia and Bergersen (1987) and Neves et al. (1981) and in this study broadly overlapped values cited by Mahon and Balon (1985) despite the fact that warm-water taxocenes are larger and so have a larger fish assemblage structure. If catastrophic flooding is minimized than this higher food production is eventually realized as fish production even in poorly buffered streams with slightly acidic water regardless of stream size. A limited comparison can also be made between fish in cold-water and warm-water streams with regards to the $P/\bar{B}$ ratio. For brook trout in small streams, $P/\bar{B}$ ratios were all less than 1.0 (Scarnecchia and Bergersen 1987) and for rainbow trout (*Oncorhyncus mykiss*) three of four values listed by Neves et al. (1985) were less than 1.4. For creek chub in Indian Creek, using mean summer biomass the $P/\bar{B}$ ratio was 2.76 while in the Speed River it was estimated at 1.65 (Mahon et al. 1979). A comparison of $P/\bar{B}$ ratios is only useful if the same seasonal biomass values are used, thus limiting generalizations that can be made. For example, Lotrich used fall biomass and his $P/\bar{B}$ ratio for creek chub in the 1st order Kentucky stream was 1.53, close to our estimate of 1.54. The annual $P/\bar{B}$ in Indian Creek varied from 1.47 to 4.42, depending on which seasonal biomass estimate was used (Table 6). Generalizations concerning $P/\bar{B}$ are difficult to make. Sparse data discussed in this study suggest $P/\bar{B}$ values are usually higher for fish in small warm-water streams (>1.5) than in those species found in cold-water streams (<1.5) This may be a function of growth rates being greater in warm-water streams since biomass values are not appreciably lower in cold-water streams of the same order. However more data are needed. Particularly interesting would be a comparison for the same species in both cold- and warm-water streams of the same order, size and flow. This would help establish whether differences in production, biomass or $P/\bar{B}$ ratios are caused by differences in species or in habitats and latitudes. We suspect habitat and latitude may have a predominant influence.

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